

# Projectile Motion

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## Horizontal Projectiles

- 1) Head-Smashed-In Buffalo Jump, near Fort Macleod, Alberta, is a UNESCO heritage site. Over 6000 years ago, the Blackfoot people of the Plains hunted the North American bison by gathering herds and directing them over cliffs 20.0 m tall. Assuming the plain was flat so that the bison ran horizontally off the cliff, and the bison were moving at their maximum speed of 18.0 m/s at the time of the fall, determine how far from the base of the cliff the bison landed. [36.3 m]
- 2) A coin rolls off a table with an initial horizontal speed of 30 cm/s. How far will the coin land from the base of the table if the table's height is 1.25 m? [15 cm]
- 3) An arrow is fired horizontally with a speed of 25.0 m/s from the top of a 150.0-m-tall cliff. Assuming no air resistance, determine the distance the arrow will drop in 2.50 s. [30.7 m]
- 4) An object is thrown horizontally off a cliff with an initial speed of 7.50 m/s. The object strikes the ground 3.0 s later. Find
  - a. the object's vertical velocity component when it reaches the ground [29 m/s [down]]
  - b. the distance between the base of the cliff and the object when it strikes the ground [23 m]
  - c. the horizontal velocity of the object 1.50 s after its release [7.50 m/s]
- 5) A baseball player throws a ball horizontally at 45.0 m/s. How far will the ball drop before reaching first base 27.4 m away? [1.82m]
- 6) An astronaut stands on the edge of a lunar crater and throws a half-eaten Twinkie™ horizontally with a velocity of 5.00 m/s. The floor of the crater is 100.0 m below the astronaut. What horizontal distance will the Twinkie™ travel before hitting the floor of the crater? (The acceleration of gravity on the moon is  $1/6^{\text{th}}$  that of the Earth). [55.3 m]
- 7) A rescue pilot drops a survival kit while her plane is flying at an altitude of 2000.0 m with a forward velocity of 100.0 m/s. If air friction is disregarded, how far in advance of the starving explorer's drop zone should she release the package? [2020 m]
- 8) A skier leaves the horizontal end of a ramp with a velocity of 25.0 m/s [E] and lands 70.0 m from the base of the ramp. How high is the end of the ramp from the ground? [38.5 m]
- 9) What is the horizontal speed of an object if it lands 40.0 m away from the base of a 100-m-tall cliff? [8.86 m/s]
- 10) Participants in a road race take water from a refreshment station and throw their empty cups away farther down the course. If a runner has a forward speed of 6.20 m/s, how far in advance of a garbage pail should he release his water cup if the vertical distance between the lid of the garbage can and the runner's point of release is 0.50 m? [2.0 m]

## Projectiles Launched at an Angle

- 1) A projectile is fired so that it has an initial vertical velocity of 22 m/s, and an initial horizontal velocity of 34 m/s.
  - a. What is the total initial velocity of the projectile? [41 m/s [33°]]
  - b. Where it is (x and y) when it has been traveling for 1.3 seconds. [44.2 m, 20.3 m]
  - c. What is the total distance it travels in the x direction if it lands at the same height it starts at. [152 m]
- 2) A trebuchet fires a projectile at an angle of  $51^\circ$  with a speed of 117 m/s. Find
  - a. The time the projectile is in the air if it is fired on level ground. [18.6 s]
  - b. The horizontal distance it covers. [1370 m]
  - c. The maximum height reached. [422 m]
- 3) Baseball players often practise their swing in a batting cage, in which a pitching machine delivers the ball. If the baseball is launched with an initial velocity of 22.0 m/s [ $30.0^\circ$ ] and the player hits it at the same height from which it was launched, for how long is the baseball in the air on its way to the batter? [2.24 s]
- 4) A paintball directed at a target is shot at an angle of  $25.0^\circ$ . If paint splats on its intended target at the same height from which it was launched, 3.00 s later, find the distance from the shooter to the target. [94.7 m]
- 5) Determine the height reached by a baseball if it is released with a velocity of 17.0 m/s [ $20^\circ$ ]. [1.73 m]
- 6) A German U2 rocket from the Second World War had a range of 300 km, reaching a maximum height of 100 km. Determine the rocket's maximum initial velocity. [ $1.75 \times 10^3$  m/s [ $53.1^\circ$ ]]
- 7) Platform divers receive lower marks if they enter the water a distance away from the platform, whereas speed swimmers dive as far out into the pool as they can. Compare and contrast the horizontal and vertical components of each type of athlete's motion.
- 8) For a fixed speed, how does the range depend on the angle,  $\theta$ ?
- 9) A golf ball is hit with an initial velocity of 30.0 m/s [ $55^\circ$ ]. What are the ball's range and maximum height? [86.2 m, 30.8 m]
- 10) During the Apollo 14 mission, Alan Shepard was the first person to hit a golf ball on the Moon. If a golf ball was launched from the Moon's surface with a velocity of 50.0 m/s [ $35^\circ$ ] and the acceleration due to gravity on the Moon is  $-1.61 \text{ m/s}^2$ ,
  - a. how long was the golf ball in the air? [35.6 s]
  - b. what was the golf ball's range? [1.5 km]
- 11) A football is thrown to a moving receiver. The football leaves the quarterback's hands 1.75 m above the ground with a velocity of 17.0 m/s [ $25^\circ$ ]. If the receiver starts 12.0 m away from the quarterback along the line of flight of the ball when it is thrown, what constant velocity must she have to get to the ball at the instant it is 1.75 m above the ground? [7.21 m/s]
- 12) At the 2004 Olympic Games in Athens, Dwight Phillips won the gold medal in men's long jump with a jump of 8.59 m. If the angle of his jump was  $23^\circ$ , what was his takeoff speed? [10.8 m/s]